CLAIMS

WHAT IS CLAIMED IS:

1. A semiconductor quantum dot device comprising:

(a) a multilayer semiconductor structure including a substrate, a back gate electrode layer, a quantum well layer, a bottom barrier layer between the quantum well layer and the back gate layer, and a top barrier layer above the quantum well layer;

(b) a plurality of spaced electrode gates formed on the multilayer semiconductor structure, the electrode gates spaced from each other by a region beneath which the quantum dot may be defined, the electrodes formed to provide a quantum dot having an elongated length and a narrow width and an asymmetric confining potential along its length such that orbital excitation of an electron in the quantum dot results in lateral center of charge motion; and

(c) a single electron sensitive electrometer adjacent to the quantum dot and coupled thereto to detect the change in charge resulting from the lateral movement of the center of charge of an electron changing orbitals in the quantum dot.

2. The device of Claim 1 further including a conductor on the semiconductor structure arranged to carry current in a direction perpendicular to the length of the quantum dot such that current carried by the conductor provides a magnetic field that extends through the quantum dot with a gradient in magnetic field along the length of the quantum dot.

3. The device of Claim 1 wherein the multilayer semiconductor structure is a heterostructure.

4. The device of Claim 1 wherein the single electron sensitive electrometer comprises a single electron transistor.

5. The device of Claim 1 further including a microwave radiator and a microwave source connected to the radiator to provide a microwave field to the quantum dot.

6. The device of Claim 5 wherein the microwave generator provides microwaves at a frequency which provides microwave energy equal to the energy splitting between the two orbitals of an electron in the quantum dot.

7. The device of Claim 6 further including means for providing a magnetic field through the quantum dot which has a gradient along the length of the quantum dot such that the two orbitals of an electron in the quantum dot have different spin splittings, and wherein the microwave generator provides microwaves at a frequency having an energy selected from the group consisting of the difference between the energy in the two orbitals of up direction spin and the difference between the energy in the two orbitals of down direction spin.

8. The device of Claim 5 wherein the microwave source is connected to at least one electrode gate which acts as the microwave radiator.

9. The device of Claim 1 wherein the back gate layer is formed of highly doped semiconductor or a quantum well containing electrons.

10. The device of Claim 1 further including a source of a magnetic field through the quantum dot that is uniform across the quantum dot.

11. The device of Claim 1 wherein the quantum well layer is formed of silicon and the top and bottom barrier layers are formed of silicon-germanium.

12. The device of Claim 11 wherein the silicon-germanium barrier layers have a thickness in the range of 30 nm and the silicon quantum well has a thickness in the range of 6 nm.

13. A multiple quantum dot device comprising:

a plurality of semiconductor quantum dot devices formed adjacent to one another in a row, each quantum dot device comprising:

(i) a multilayer semiconductor structure, on which all of the quantum dot devices are formed, including a substrate, a back gate electrode layer, a quantum well layer, a bottom barrier layer between the quantum well layer and the back gate layer, and a top barrier layer above the quantum well layer;

(ii) each quantum dot device having a plurality of spaced electrode gates formed on the multilayer semiconductor structure, the electrode gates spaced from each other by a region beneath which the quantum dot may be defined, the electrodes formed to provide a quantum dot having an elongated length and narrow width and an

asymmetric confining potential along its length such that orbital excitation of an electron in the quantum dot results in lateral center of charge motion; and

(iii) each quantum dot device having a single electron sensitive electrometer adjacent to the quantum dot and coupled thereto to detect the change in charge resulting from the lateral movement of the center of charge of an electron changing orbitals in the quantum dot;

wherein each quantum dot device shares gate electrodes with a quantum dot device next to it.

14. The multiple quantum dot device of Claim 13 further including a conductor on the semiconductor structure arranged to carry current in a direction perpendicular to the length of the quantum dot such that current carried by the conductor provides a magnetic field that extends through the quantum dot with a gradient in magnetic field along the length of the quantum dot.

15. The multiple quantum dot device of Claim 13 wherein the multilayer semiconductor structure is a heterostructure.

16. The multiple quantum dot device of Claim 13 wherein the single electron sensitive electrometer for each quantum dot device comprises a single electron transistor.

17. The multiple quantum dot device of Claim 13 further including a microwave radiator and a microwave source connected to the radiator to provide a microwave field to each of the quantum dots.

18. The multiple quantum dot device of Claim 17 wherein the microwave generator provides microwaves at a frequency which provides microwave energy equal to the energy splitting between the two orbitals of an electron in the quantum dot of a quantum dot device.

19. The multiple quantum dot device of Claim 18 further including means for providing a magnetic field through the quantum dot of each quantum dot device which has a gradient along the length of the quantum dot such that the two orbitals of an electron in the quantum dot have different spin splittings, and wherein the microwave generator provides microwaves at a frequency having an energy selected from the group consisting of the difference between the energy in the two orbitals of up direction spin and the difference between the energy in the two orbitals of down direction spin.

20. The multiple quantum dot device of Claim 17 wherein the microwave source is connected to at least one electrode gate for each quantum dot, which acts as the microwave radiator.

21. The multiple quantum dot device of Claim 13 wherein the back gate layer is formed of highly doped semiconductor or a quantum well containing electrons.

22. The multiple quantum dot device of Claim 13 wherein the quantum well layer is formed of silicon and the top and bottom barrier layers are formed of silicon-germanium.

23. The multiple quantum dot device of Claim 22 wherein the silicon-germanium barrier layers have a thickness in the range of 30 nm and the silicon quantum well has a thickness in the range of 6 nm.

24. The multiple quantum dot device of Claim 13 further including a source of magnetic field through the quantum dot that is uniform across the quantum dot.

25. A method of carrying out quantum dot manipulation in a semiconductor quantum dot comprising:

(a) providing a multilayer semiconductor structure with electrodes to provide a quantum dot having an elongated length and a narrow width and an asymmetric confining potential along its length such that orbital excitation of an electron in the quantum dot results in lateral center of charge motion; and

(b) applying microwaves to the quantum dot at a frequency corresponding to the difference in energy between the two orbitals to provide lateral motion of the center of charge in the quantum dot.

26. The method of Claim 25 further including detecting the motion of the center of charge with a charge detector.

27. The method of Claim 25 further including applying a magnetic field to the quantum dot so that motion of the charge is generated in a spin-dependent fashion and wherein the microwave radiation is provided to the quantum dot at a frequency corresponding to the difference in energy of the spin down state of the electron in the orbital ground state and in the excited state.

28. The method of Claim 27 wherein microwave radiation is applied to the quantum dot to initialize the quantum dot so that the spin of the electron in the quantum dot is initialized to an up spin in the ground state.

29. The method of Claim 28 further including after initialization, applying microwave radiation to the quantum dot at a readout frequency selected to cause charge motion only if the electron in the quantum dot is in the down spin state at the time of measurement.